GUEST EDITORIAL

INTERNET OF THINGS AND INFORMATION PROCESSING IN SMART ENERGY APPLICATIONS

				
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There are several challenges for the current electricity grid: growing electricity demand, an aging grid infrastructure, ever-increasing penetration of renewables, and significant uptake of electric vehicles and energy storage with behind-the-meter applications for residential and commercial buildings. To address these challenges, there must be strong and low-cost communications infrastructures that can support rapid and secure information exchange as well as consistent and efficient design of communication protocols and architectures to enable automation and effective use of smart energy resources.

The Internet of Things (IoT) could accelerate establishment of such infrastructures. With IoT technologies, many more devices could be controlled and managed through the Internet; data pertaining to the grid, commercial buildings, and residential premises can be readily collected and utilized. To derive valuable information from the data, further information and data processing becomes essential.

This Feature Topic aims to disseminate general ideas extracted from cutting-edge research results relevant to smart energy applications from the perspectives of IoT, and advanced information processing and communications technologies. We received 23 submissions from around the world and selected 6 papers for publication (26% acceptance rate). The authors of these accepted papers share various viewpoints and the latest findings from their research and ongoing projects.

For smart grid applications, we need to predict the electrical load so that the underlying smart grid can effectively balance the power supply and demand. In general, predictions are made based on the data obtained using IoT and smart meter technologies. While collecting data becomes easier to manage, analyzing it becomes more complex and time-consuming because of the 4V properties of big data, i.e., volume, velocity, variety, and veracity. Conventional methods seem to struggle with analyzing complicated data relationships. Our first article entitled ``When Weather Matters: IoT-based Electrical Load Forecasting for Smart Grid'' addresses this difficulty. An IoT-based deep learning system is presented that can automatically extract features from captured big data, ultimately yielding accurate estimation of future loads.

To successfully realize smart energy management, we need a robust communications infrastructure for ubiquitous, large-scale, and reliable information exchange among sensors and actuators. The robustness is essential because sensors and actuators deployed in the field will often have little or no human interaction. Two relevant studies are included. The second article, ``Software Defined Machine-to-Machine Communication for Smart Energy Management,'' discusses an interesting software-defined machine-to-machine framework. Under this framework, cost reduction, fine granularity resource allocation, and end-to-end quality of service are considered. Several open issues and key research opportunities are identified. The third article, ``5G Mobile Cellular Networks: Enabling Distributed State Estimation for Smart Grids,'' presents advanced distributed state estimation methods in a 5G environment. Emerging distributed state estimation solutions are provided, and their integration as part of the future 5G-based smart grid services are investigated.

We cannot emphasize enough the importance of data security when IoT technologies are employed for smart energy applications. There is an increasing need for defense mechanisms that either protect the system from attackers in advance or detect data injection attacks in real time. A comprehensive tutorial and survey regarding data security threats and associated research challenges can be found in the fourth article, ``Energy Big Data Security Threats in IoT-based Smart Grid Communications.'' The fifth article entitled ``Defense Mechanisms against Data Injection Attacks in Smart Grid Networks'' investigates relevant signal processing techniques and introduces an adaptive scheme for detecting malicious data injection. Another solution to secure communications is the use of power talk, a low-rate communication technique for direct current microgrids. This technique may support several smart energy applications and is reviewed in the sixth article, ``Resilient and Secure Low-Rate Connectivity for Smart Energy Applications through Power Talk in DC Microgrids.''

These 6 articles provide an excellent overview on advanced technologies for smart energy applications. We would like to thank the authors and reviewers for their contributions and support. We also hope this Feature Topic can motivate researchers in academia, practitioners in industry, and officials in government to explore more possibilities in this exciting area in the future.

BIOGRAPHIES

Wei-Yu Chiu [M’11] received his Ph.D. degree in communications engineering from National Tsing Hua University (NTHU), Hsinchu, Taiwan in 2010. He was a Postdoctoral Research Fellow with Princeton University from 2011 to 2012 and a Visiting Scholar with Oklahoma State University in 2015. He is currently an Assistant Professor of Electrical Engineering with NTHU. His research interests include multiobjective control, smart grid, and computational intelligence.

Hongjian Sun [S’07-M’11-SM’15] received his Ph.D. degree from the University of Edinburgh (U.K.) in 2011 and then took postdoctoral positions at King’s College London (U.K.) and Princeton University (USA). Since 2013, he has been with the University of Durham, U.K., as an Assistant Professor (2013-2017) and then an Associate Professor (Reader). His research mainly focuses on smart grid areas: (i) communications and networking, (ii) demand side management and demand response, and (iii) renewable energy sources integration.

John Thompson [M’94-SM’13-F’16] currently holds a personal chair in Signal Processing and Communications in University of Edinburgh, UK. He was deputy academic coordinator for Mobile Virtual Centre of Excellence Green Radio project and now leads the UK SERAN project for 5G wireless. He also currently leads the European Marie Curie Training Network ADVANTAGE which trains 13 PhD students in Smart Grids. He was a distinguished lecturer on green topics for ComSoc in 2014-2015.

Kiyoshi Nakayama [M'14] completed his Ph.D. degree in Computer Science at the University of California, Irvine in June, 2014, and then belonged to Fujitsu Laboratories of America as a Postdoctoral Research Associate in smart energy research group. Since 2015, he has been a Researcher at NEC Laboratories America to lead the microgrid and behind-the-meter project for developing and deploying a cloud-based autonomous energy management platform with intelligent data and model driven approaches.

Shunqing Zhang [S'05-M'09-SM'14] received the Ph.D. degree in 2009 from the Department of Electrical and Computer Engineering, Hong Kong University of Science and Technology, Hong Kong. He was a senior researcher with Huawei, and then a research scientist & deputy director of ICRI-MNC, Intel Labs. He is currently a full Professor in Shanghai University, China. His current research interests include cellular network intelligence, energy efficient 5G communication networks, non-orthogonal waveform design.